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(54) Chip antenna having multiple resonance frequencies

Chip-Antenne mit Mehrfach-Resonanzfrequenzen

Antenne monopuce à fréquences de résonance multiples

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EP-A- 0 759 646
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- IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, vol. 43, no. 3, March 1995, NEW YORK US, pages 227-231, XP000497006 SHEN ET AL.: "Study of Gain Enhancement Method for Microstrip Antennas Using Moment Method"

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Description

[0001] The present invention relates to chip antennas and particularly a chip antenna used for mobile communication and local area networks (LAN).

[0002] Conventional antennas include monopole antennas and chip antennas, for example.

[0003] Fig. 9 shows a typical prior art monopole antenna 1. The monopole antenna 1 has a conductor 2 perpendicular to an earth plate (not shown in the figure) in air (dielectric constant e = 1 and relative permeability m = 1), the one end 3 of the conductor 2 forming a feeding section and the other end 4 being a free end.

[0004] Fig. 10 is a side view of a typical prior art chip antenna 5. The chip antenna 5 comprises an insulator 6, a coil conductor 7, a magnetic member 8, and external connecting terminals 9a and 9b.

[0005] Each of the prior art monopole antenna and chip antenna set forth above has only one feeding section and conductor, and thus has only one resonance frequency. Thus, a plurality of monopole antennas or chip antennas are required for responding to two or more different resonance frequencies, and they are not applicable to uses, requiring compact antennas, such as mobile communication, for the reason of their sizes.

[0006] EP 0 759 646, which is a prior art document under Art. 54(3) EPC, relates to a chip antenna. It comprises a substrate comprising at least one of a dielectric material and a magnetic material, and a plurality of layers stacked on each other establishing a direction normal to the stacked layers and spirally wound conductors disposed on at least one of a surface of said substrate and inside said substrate and having a spiral axis extending perpendicular to the direction normal to the stacked layers.

[0007] EP 0 427 654 A1 discloses an antenna having two spiral conductors which are arranged coaxial to each other and extend along a longitudinal axis of a substrate.

[0008] WO94/17565 discloses an antenna assembly for a radio circuit having a first antenna portion formed of a one-half wavelength helical winding, and a second antenna portion comprised of a helical winding. The first antenna portion it positioned at a distal side of a nonconductive whip and the second helical winding is supported at a proximal side of the nonconductive whip.

[0009] It is the object underlying the present invention to provide a compact chip antenna which can respond to a plurality of resonance frequencies, and thus can be used for mobile communication and alike.

[0010] This object is achieved by a chip antenna according to claim 1.

[0011] Because the chip antenna in accordance with the present invention has a plurality of conductors, the single chip antenna can respond to a plurality of resonance frequencies.

[0012] Other features and advantages of the present invention will become apparent from the following description of the invention which refers to the accompanying drawings.

Fig. 1 is an isometric view illustrating a chip antenna;

Fig. 2 is a decomposed isometric view of the chip antenna in Fig. 1;

Fig. 3 is a graph illustrating reflection loss characteristics of the chip antenna in Fig. 1;

Fig. 4 is an isometric view illustrating an embodiment of a chip antenna in accordance with the present invention;

Fig. 5 is a decomposed isometric view of the chip antenna in Fig. 4;

Fig. 6 is a graph illustrating reflection loss characteristics of the chip antenna in Fig. 4;

Fig. 7 is an isometric view illustrating a chip antenna;

Fig. 8 is a graph illustrating reflection loss characteristics of the chip antenna in Fig. 7;

Fig. 9 is a schematic view of a conventional monopole antenna; and

Fig. 10 is a side view of a conventional chip antenna.

[0013] Embodiments in accordance with the present invention will now be explained with reference to drawings.

[0014] Fig. 1 is an isometric view illustrating a chip antenna, and Fig. 2 is a decomposed isometric view of the chip antenna as it is disclosed in EP 0 759 646.

[0015] The chip antenna 10 comprises meander conductors 12a and 12b each having a plurality of corners in a rectangular parallelopiped substrate 11. The substrate 11 is formed by laminating rectangular dielectric sheet layers 13a through 13e each comprising a dielectric material (dielectric constant = ca. 6.1) mainly containing barium oxide, aluminum oxide and silica. Meander conductors 12a and 12b comprising copper or a copper alloy are provided on the surfaces of the sheet layers 13b and 13d by printing, evaporation, adhesion, or plating. A via hole 14 is provided at the one end of the conductor 12b on the sheet layer 13d and through the layer 13c. Two meander conductors 12a and 12b are formed inside the substrate 11 by laminating the sheet layers 13a through 13e, where the one end of the conductor 12a and the one end of the conductor 12b connect with each other through the via hole 14 inside the substrate 11.

[0016] The other end of the conductor 12a is drawn out to the surface of the substrate 11 to form a feeding section 16 which connects with a feeding terminal 15 formed on the surface of the substrate 11 for applying a voltage to the conductors 12a and 12b. The other end of the conductor 12b forms a free end 17 inside the substrate 11. In this case, the conductors 12a and 12b connect with each other through the via hole 14 in series to the feeding terminal 15.

[0017] Fig. 3 is a graph illustrating the reflection loss characteristics of the antenna 10. The antenna 10, in which the conductors 12a and 12b connect with each other in series, exhibits a resonance frequency corresponding to the conductor 12a at approximately 2.17 [GHz] (b1 in Fig. 3), a resonance frequency corresponding to the conductor 12b at approximately 2.27 [GHz] (c1 in Fig. 3), and a resonance frequency due to the coupling of the conductors 12a and 12b at approximately 1.56 [GHz] (a1 in Fig. 3). Accordingly, the antenna in the embodiment set forth above can respond to three different resonance frequencies, i.e, 1.56 [GHz], 2.17 [GHz], and 2.27[GHz].

[0018] Fig. 4 and Fig. 5 are an isometric view and a decomposed isometric view, respectively, illustrating an embodiment of a chip antenna in accordance with the present invention.

[0019] The chip antenna 20 is provided with two conductors 22a and 22b spirally coiled inside a rectangular parallelopiped substrate 21 in the longitudinal direction of the substrate 21. The substrate 21 comprises rectangular sheet layers 23a through 23e comprising a dielectric material, e.g., having a dielectric constant = ca. 6.1 and mainly containing barium oxide, aluminum oxide and silica. The sheet layers 23a through 23d are provided with L-shape or linear conductive patterns 24a through 24h and 25a through 25h each comprising, e. g., copper or a copper alloy on the surfaces of their respective sheet layers, by printing, evaporation, adhesion and plating. Further, via holes 26a are provided at both ends of the conductors 24e through 24g and 25e through 25g and at the one end (26b) of the conductors 24h, 25a and 25h on the sheet layer 23b through 23d along the vertical direction. When the sheet layers 23a through 23e are stacked and the conductive patterns 24a through 24h and 25a through 25h connect with each other through via holes 26, spirally coiled conductors 22a and 22b each having a rectangular cross-section are formed. The one end of the conductor 22a and the one end of the conductor 22b connect with each other through a via hole 26b.

[0020] Further, the one of the ends of conductors 22a and 22b (one of the ends of conductive patterns 24a and 25a) are drawn out at the surface of the substrate 21 to form a feeding section 27 which connects with the feeding terminal 15 on the surface of the substrate 21. The other ends of the conductors 22a and 22b (the other ends of conductive patterns 24h and 25h) form free ends 28a and 28b, respectively, inside the substrate 21. In this case, the conductors 22a and 22b connect with each other in parallel to the feeding terminal 15 through the via hole 26b.

[0021] Fig. 6 is a graph illustrating reflectance loss characteristics of the antenna 20. Fig. 6 demonstrates that a resonance frequency for the conductor 22a appears near 1.50 [GHz] (a2 in the figure), a resonance frequency for the conductor 22b appears near 2.09 [GHz] (b2 in the figure), and a resonance frequency due to coupling of the conductors 22a and 22b appears near 2.66 [GHz] (c2 in the figure).

[0022] As set forth above, this antenna can respond to three different resonance frequencies, i.e., 1.50 [GHz], 2.09 [GHz], and 2.66 [GHz].

[0023] Fig. 7 is an isometric view of a chip antenna.

[0024] The chip antenna 30 comprises a rectangular parallelopiped substrate 31 comprising a dielectric material, for example, having a dielectric constant: ca. 6.1 and mainly containing barium oxide, aluminum oxide and silica; conductors 32a and 32b which comprise, e. g., copper or a copper alloy, and is spirally coiled inside the substrate 31 along the longitudinal direction; and feeding terminals 33a and 33b provided at the side, top face and bottom face for applying a voltage to the conductors 32a and 32b. The one ends of the conductors 32a and 32b form feeding sections 34a and 34b which connect with feeding terminals 33a and 33b, respectively. The other ends of the conductors 32a and 32b form free ends 35a and 35 inside the substrate 31. In this case, the conductors 32a and 32b are independently formed inside the substrate 31.

[0025] Fig. 8 is a graph illustrating reflectance loss characteristics of the antenna 30 comprising the conductors 32a and 32b formed independently. Fig. 8 demonstrates that a resonance frequency for the conductor 32a appears near 0.85 [GHz] (a3 in the figure), a resonance frequency for the conductor 32b appears near 1.50 [GHz] (b3 in the figure), and a resonance frequency corresponding to the second harmonic of the conductor 32a appears near 1.55 [GHz] (c3 in the figure).

[0026] As set forth above, the antenna can respond to two different resonance frequencies at 0.85 [GHz], and 1.50 [GHz]. Further, the bandwidth near 1.50 [GHz] can be expanded by the second harmonic.

[0027] In this case, when the conductors 32a and 32b are provided so that the coiling axis of the conductor 32a is perpendicular to that of the conductor 32b, coupling between two conductors can be suppressed, and thus the resonance frequency can be readily controlled.

[0028] In the embodiment set forth above, although the substrate of each chip antenna comprises a dielectric material mainly containing barium oxide, aluminum oxide and silica, other dielectric materials mainly containing titanium oxide and/or neodymium oxide, magnetic materials mainly containing nickel, cobalt, and/or iron, and combinations of dielectric materials and magnetic materials also can be used as the substrate.

[0029] Although each antenna has two conductors in

the embodiment set forth above, the antenna can have three or more conductors for providing more resonance frequencies. For example, the antenna having three conductors can respond to four different resonance frequencies.

[0030] The conductors can be provided on at least one side of the surface of the substrate and inside the substrate, other than inside of the substrate as set forth in each embodiment.

[0031] Further, the feeding terminal can be provided at any appropriate position of the substrate, and is not limited to the positions shown.

[0032] Since the chip antenna in accordance with the present invention having a plurality of conductors can respond to a plurality of resonance frequencies, a multi-band antenna system can be achieved. Further, the band width can be expanded by adjoining a plurality of resonance frequencies to each other.

Claims

1. A chip antenna (20), comprising:

   a substrate (21) comprising at least one of a dielectric material and a magnetic material, and a plurality of layers (23a-e) stacked on each other establishing a direction normal to the stacked layers (23a-e);

   a first spirally wound conductor (22a) disposed on at least one of a surface of said substrate (21) and inside said substrate, the first spirally wound conductor (22a) having a spiral axis extending perpendicular to the direction normal to the stacked layers (23a-e);

   a second spirally wound conductor (22b) disposed on at least one of a surface of said substrate (21) and inside said substrate, the second spirally wound conductor (22b) having a spiral axis extending perpendicular to the direction normal to the stacked layers (23a-e); and

   at least one feeding terminal (15) provided on the surface of said substrate (21) and connected to a common end of the conductors (22a, 22b) for applying a voltage to said conductors.

2. A chip antenna (20) according to claim 1, wherein said chip antenna further comprises at least one fixing terminal to fix said substrate to a mounting board.

3. A chip antenna (20) according to claim 1 or 2 wherein portions of said first conductor (22a) are disposed on at least two layers, portions of said second conductor (22b) are disposed on at least two layers, a conductive through hole being provided in at least one of said layers connecting respective portions of the first conductor (22a) together when the layers are laminated together and a conductive through hole being provided in at least one of said layers connecting respective portions of the second conductor (22b) together when the layers are laminated together.

4. A chip antenna (20) according to one of claims 1 to 3, wherein said chip antenna has a plurality of resonance frequencies due to said two conductors.

5. A chip antenna (20),according to claim 1, wherein both said conductors (22a, 22b) have a free end (28a, 28b).

6. A chip antenna (20) according to one of claims 1 to 5, wherein the conductors (22a, 22b) comprise copper or a copper alloy.

7. A chip antenna (20) according to one of claims 1 to 6, wherein the substrate (21) comprises a combination of a dielectric and a magnetic material.

8. A chip antenna (20) according to one of claims 1 to 7, wherein the dielectric material comprises barium oxide, aluminum oxide and silica.

9. A chip antenna (20) according to one of claims 1 to 7, wherein the dielectric material comprises at least one of titanium oxide and neodymium oxide.

10. A chip antenna (20) according to one of claims 1 to 9, wherein the magnetic material comprises at least one of nickel, cobalt and iron.

11. A chip antenna (20) according to claim 1, wherein the chip antenna has three resonance frequencies.

12. A chip antenna according to claim 1, wherein the substrate is mounted on a board extending in a first direction, the conductors being arranged to have a longitudinal extent in the first direction.

13. A chip antenna according to claim 1, wherein the substrate is mounted on a board extending in a first direction, the conductors being arranged to have a longitudinal extent in a second direction substantially perpendicular to the first direction.

14. A chip antenna according to claim 11, wherein at least two of the resonance frequencies are spaced close together so that an area of extended bandwidth can be achieved near the two resonance frequencies.

15. A chip antenna (20) according to one of claims 1 to

15, wherein the substrate comprises a rectangulär parallelepiped.

16. A chip antenna (20) according to claim 1, wherein said spiral conductor has a rectangular cross section.

Patentansprüche

1. Eine Chip-Antenne (20), die folgende Merkmale aufweist:

   ein Substrat (21), das zumindest entweder ein dielektrisches Material oder ein magnetisches Material sowie eine Mehrzahl von aufeinandergestapelten Schichten (23a-e) aufweist, die eine normal zu den gestapelten Schichten (23a-e) verlaufende Richtung festlegen;

   einen ersten spiralförmig gewendelten Leiter (22a), der mindestens entweder auf einer Oberfläche des Substrats (21) oder in dem Substrat angeordnet ist, wobei der erste spiralförmig gewendelte Leiter (22a) eine Spiral-Achse aufweist, die sich senkrecht zu der normal zu den gestapelten Schichten (23a-e) verlaufenden Richtung erstreckt;

   einen zweiten spiralförmig gewendelten Leiter (22b), der mindestens entweder auf einer Oberfläche des Substrats (21) oder in dem Substrat angeordnet ist, wobei der zweite spiralförmig gewendelte Leiter (22b) eine Spiral-Achse aufweist, die sich senkrecht zu der normal zu den gestapelten Schichten (23a-e) verlaufenden Richtung erstreckt; und

   mindestens einen Zuführanschluß (15), der auf der Oberfläche des Substrats (21) vorgesehen ist und mit einem gemeinsamen Ende der Leiter (22a, 22b) verbunden ist, um eine Spannung an die Leiter anzulegen.

2. Eine Chip-Antenne (20) gemäß Anspruch 1, wobei die Chip-Antenne ferner zumindest einen Befestigungsanschluß aufweist, um das Substrat an einer Befestigungsplatine zu befestigen.

3. Eine Chip-Antenne (20) gemäß Anspruch 1 oder 2, bei der Abschnitte des ersten Leiters (22a) auf mindestens zwei Schichten angeordnet sind, bei der Abschnitte des zweiten Leiters (22b) auf mindestens zwei Schichten angeordnet sind, bei der ein leitfähiges Durchkontaktierungsloch in mindestens einer der Schichten vorgesehen ist, das jeweilige Abschnitte des ersten Leiters (22a) miteinander verbindet, wenn die Schichten miteinander laminiert sind, und bei der ein leitfähiges Durchkontaktierungsloch in mindestens einer der Schichten vorgesehen ist, die jeweilige Abschnitte des zweiten Leiters (22b) miteinander verbinden, wenn die Schichten miteinander laminiert sind.

4. Eine Chip-Antenne (20) gemäß einem der Ansprüche 1 bis 3, wobei die Chip-Antenne eine Mehrzahl von Resonanzfrequenzen aufweist, die auf die zwei Leiter zurückzuführen sind.

5. Eine Chip-Antenne (20) gemäß Anspruch 1, bei der beide Leiter (22a, 22b) ein freies Ende (28a, 28b) aufweisen.

6. Eine Chip-Antenne (20) gemäß einem der Ansprüche 1 bis 5, bei der die Leiter (22a, 22b) Kupfer oder eine Kupferlegierung aufweisen.

7. Eine Chip-Antenne (20) gemäß einem der Ansprüche 1 bis 6, bei der das Substrat (21) eine Kombination aus einem dielektrischen und einem magnetischen Material aufweist.

8. Eine Chip-Antenne (20) gemäß einem der Ansprüche 1 bis 7, bei der das dielektrische Material Bariumoxid, Aluminiumoxid und Siliziumdioxid aufweist.

9. Eine Chip-Antenne (20) gemäß einem der Ansprüche 1 bis 7, bei der das dielektrische Material zumindest entweder Titanoxid oder Neodymoxid aufweist.

10. Eine Chip-Antenne (20) gemäß einem der Ansprüche 1 bis 9, bei der das magnetische Material zumindest entweder Nickel, Kobalt oder Eisen aufweist.

11. Eine Chip-Antenne (20) gemäß Anspruch 1, wobei die Chip-Antenne drei Resonanzfrequenzen aufweist.

12. Eine Chip-Antenne gemäß Anspruch 1, bei der das Substrat an einer Platine angebracht ist, die sich in einer ersten Richtung erstreckt, wobei die Leiter angeordnet sind, um eine longitudinale Erstreckung in die erste Richtung aufzuweisen.

13. Eine Chip-Antenne gemäß Anspruch 1, bei der das Substrat an einer Platine angebracht ist, die sich in einer ersten Richtung erstreckt, wobei die Leiter angeordnet sind, um eine longitudinale Erstreckung in eine zweite Richtung, die im wesentlichen senkrecht zu der ersten Richtung ist, aufzuweisen.

14. Eine Chip-Antenne gemäß Anspruch 11, bei der zumindest zwei der Resonanzfrequenzen nahe bei-

einander angeordnet sind, so daß ein Bereich einèr erweiterten Bandbreite in der Nähe der beiden Resonanzfrequenzen erreicht werden kann.

15. Eine Chip-Antenne (20) gemäß einem der Ansprüche 1 bis 14, bei der das Substrat ein rechteckiges Parallelepiped aufweist.

16. Eine Chip-Antenne (20) gemäß Anspruch 1, bei der der spiralförmige Leiter einen rechteckigen Querschnitt aufweist.

Revendications

1. Antenne (20) sous forme de circuit intégré, comprenant :

    un substrat (21) comprenant au moins l'une d'une matière diélectrique et d'une matière magnétique, et plusieurs couches (23a à e) empilées les unes sur les autres en établissant une direction normale aux couches empilées (23a à e) ;
    un premier conducteur (22a) enroulé en spirale disposé sur au moins l'un d'une surface dudit substrat (21) et de l'intérieur dudit substrat, le premier conducteur (22a) enroulé en spirale ayant un axe de spirale s'étendant perpendiculairement à la direction normale aux couches empilées (23a à e) ;
    un second conducteur (22b) enroulé en spirale disposé sur au moins l'un d'une surface dudit substrat (21) et de l'intérieur dudit substrat, le second conducteur (22b) enroulé en spirale ayant un axe de spirale s'étendant perpendiculairement à la direction normale aux couches empilées (23a à e) ; et
    au moins une borne (15) d'alimentation disposée sur la surface dudit substrat (21) et connectée à une extrémité commune des conducteurs (22a, 22b) pour appliquer une tension auxdits conducteurs.

2. Antenne (20) sous forme de circuit intégré selon la revendication 1, dans laquelle ladite antenne sous forme de circuit intégré comprend en outre au moins une borne de fixation pour fixer ledit substrat à une carte de montage.

3. Antenne (20) sous forme de circuit intégré selon la revendication 1 ou 2, dans laquelle des parties dudit premier conducteur (22a) sont disposées sur au moins deux couches, des parties dudit second conducteur (22b) sont disposées sur au moins deux couches, un trou traversant conducteur étant disposé dans au moins l'une desdites couches en reliant ensemble des parties respectives du premier conducteur (22a) lorsque les couches sont stratifiées ensemble, et un trou traversant conducteur étant disposé dans au moins l'une desdites couches en reliant ensemble des parties respectives du second conducteur (22b), lorsque les couches sont stratifiées ensemble.

4. Antenne (20) sous forme de circuit intégré selon l'une des revendications 1 à 3, dans laquelle ladite antenne sous forme de circuit intégré possède plusieurs fréquences de résonance en raison desdits deux conducteurs.

5. Antenne (20) sous forme de circuit intégré selon la revendication 1, dans laquelle lesdits deux conducteurs (22a, 22b) ont une extrémité libre (28a, 28b).

6. Antenne (20) sous forme de circuit intégré selon l'une des revendications 1 à 5, dans laquelle les conducteurs (22a, 22b) comprennent du cuivre ou un alliage de cuivre.

7. Antenne (20) sous forme de circuit intégré selon l'une des revendications 1 à 6, dans laquelle le substrat (21) comprend une combinaison d'un diélectrique et d'une matière magnétique.

8. Antenne (20) sous forme de circuit intégré selon l'une des revendications 1 à 7, dans laquelle la matière diélectrique comprend de l'oxyde de baryum, de l'oxyde d'aluminium et de la silice.

9. Antenne (20) sous forme de circuit intégré selon l'une des revendications 1 à 7, dans laquelle la matière diélectrique comprend au moins l'un de l'oxyde de titane et de l'oxyde de néodyme.

10. Antenne (20) sous forme de circuit intégré selon l'une des revendications 1 à 9, dans laquelle la matière magnétique comprend au moins l'un du nickel, du cobalt et du fer.

11. Antenne (20) sous forme de circuit intégré selon la revendication 1, dans laquelle l'antenne formée sur circuit intégré possède trois fréquences de résonance.

12. Antenne sous forme de circuit intégré selon la revendication 1, dans laquelle le substrat est monté sur une carte s'étendant dans une première direction, les conducteurs étant agencés pour avoir une étendue longitudinale dans la première direction.

13. Antenne sous forme de circuit intégré selon la revendication 1, dans laquelle le substrat est monté sur une carte s'étendant dans une première direction, les conducteurs étant agencés pour avoir une étendue longitudinale dans une seconde direction

sensiblement perpendiculaire à la première direction.

14. Antenne sous forme de circuit intégré selon la revendication 11, dans laquelle au moins deux des fréquences de résonance sont étroitement rapprochées l'une de l'autre de façon à pouvoir obtenir une zone de largeur de bande étendue près des deux fréquences de résonance.

15. Antenne (20) sous forme de circuit intégré selon l'une des revendications 1 à 15, dans laquelle le substrat comprend un parallélépipède rectangle.

16. Antenne (20) sous forme de circuit intégré selon la revendication 1, dans laquelle ledit conducteur en spirale a une section transversale rectangulaire.

FIG. 1

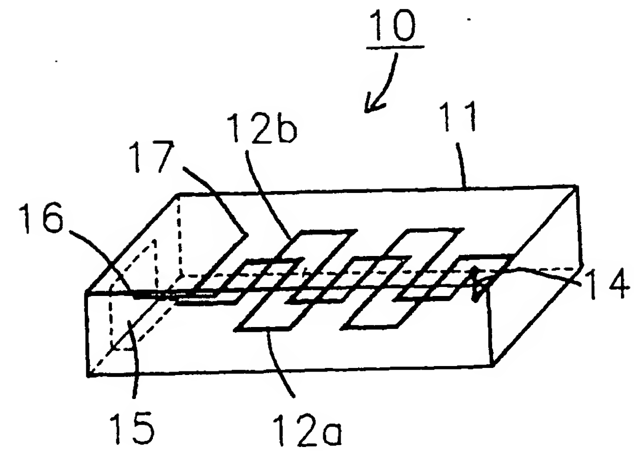
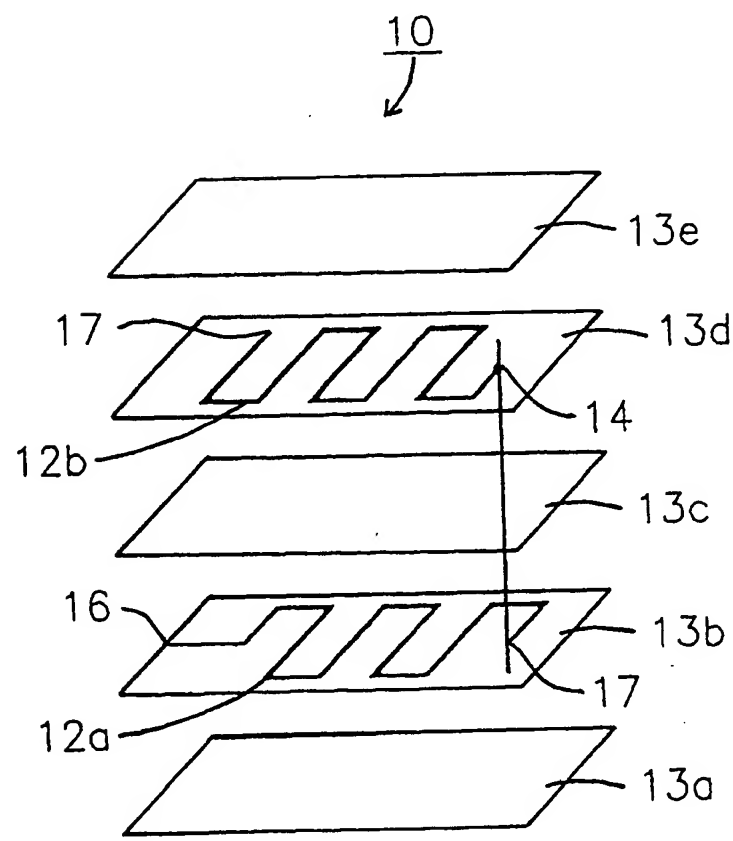


FIG. 2



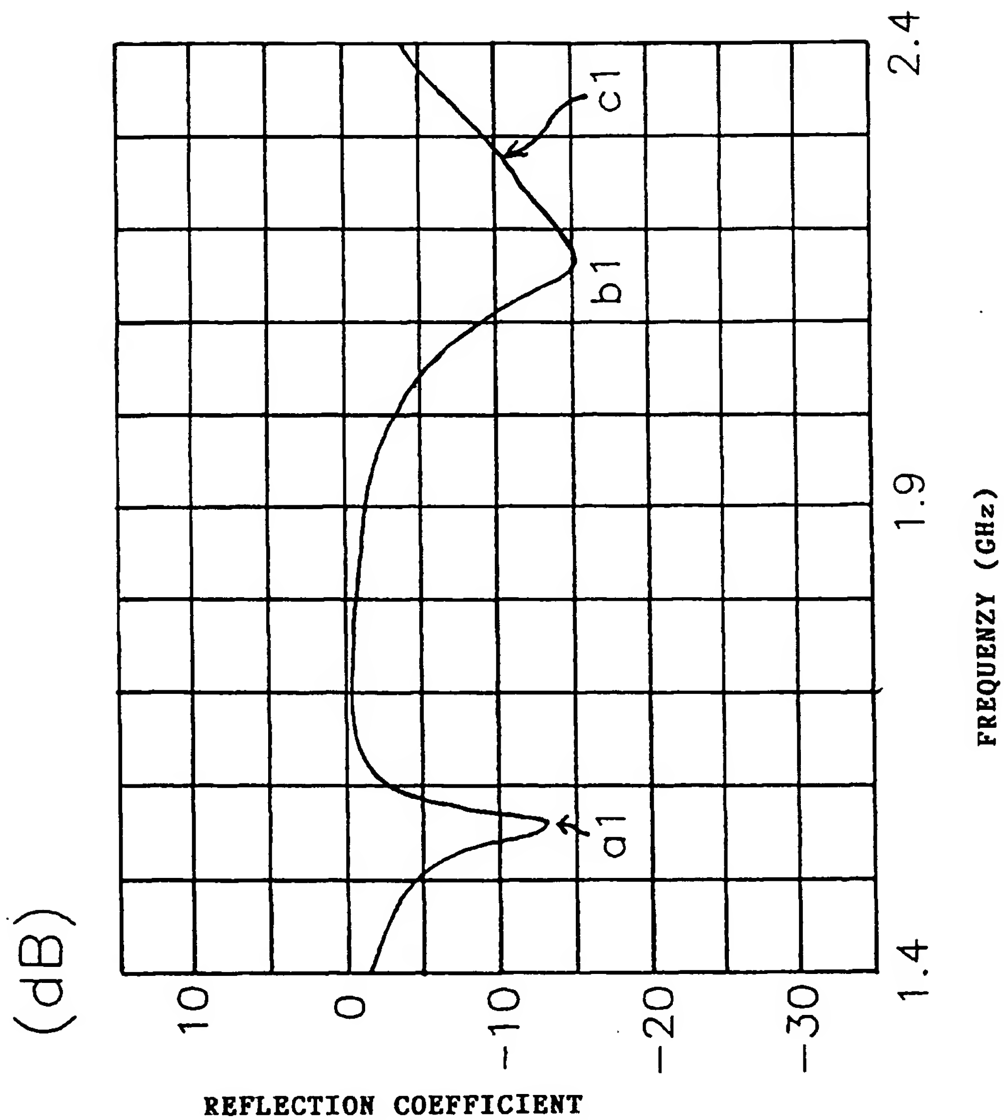

(dB)
10
0
-10
-20
-30
REFLECTION COEFFICIENT
1.4
1.9
2.4
FREQUENZY (GHz)
a1
b1
c1

FIG. 3

FIG. 4

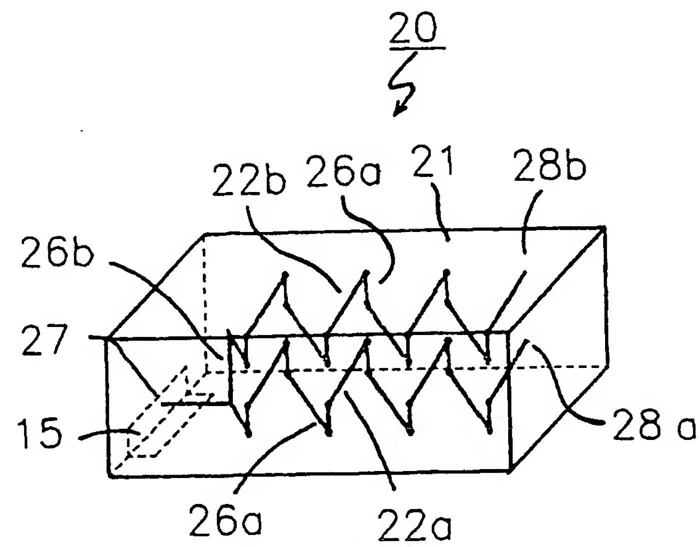
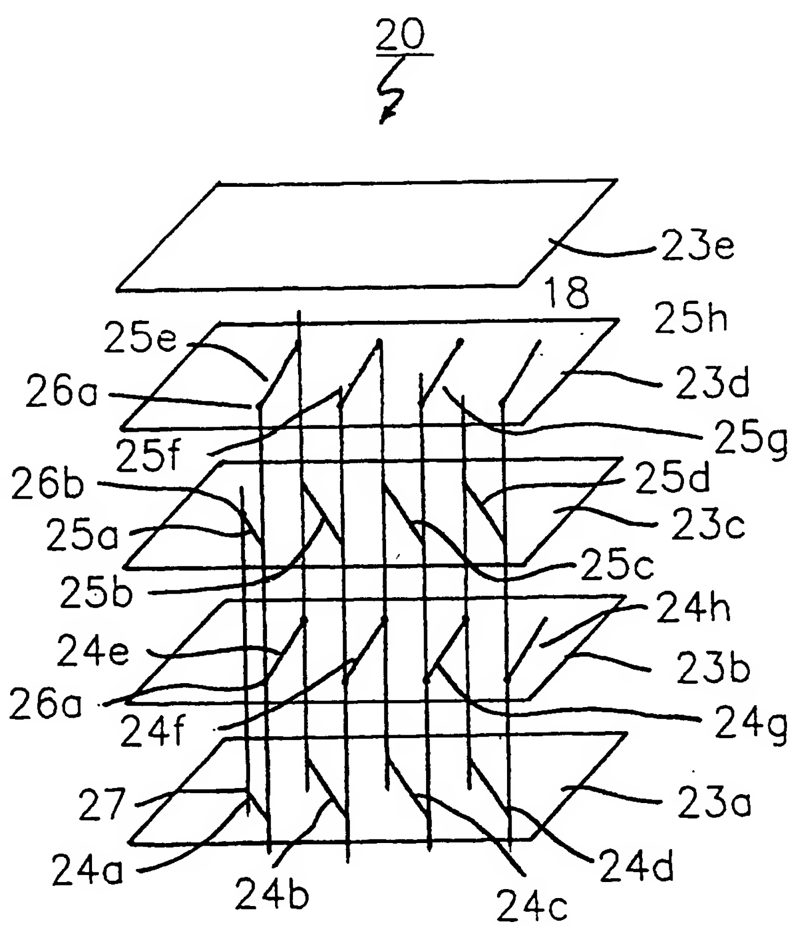

20
22b
26a
21
28b
26b
27
15
28 a
26a
22a

FIG. 5


20
23e
18
25h
25e
23d
26a
25g
25f
25d
26b
23c
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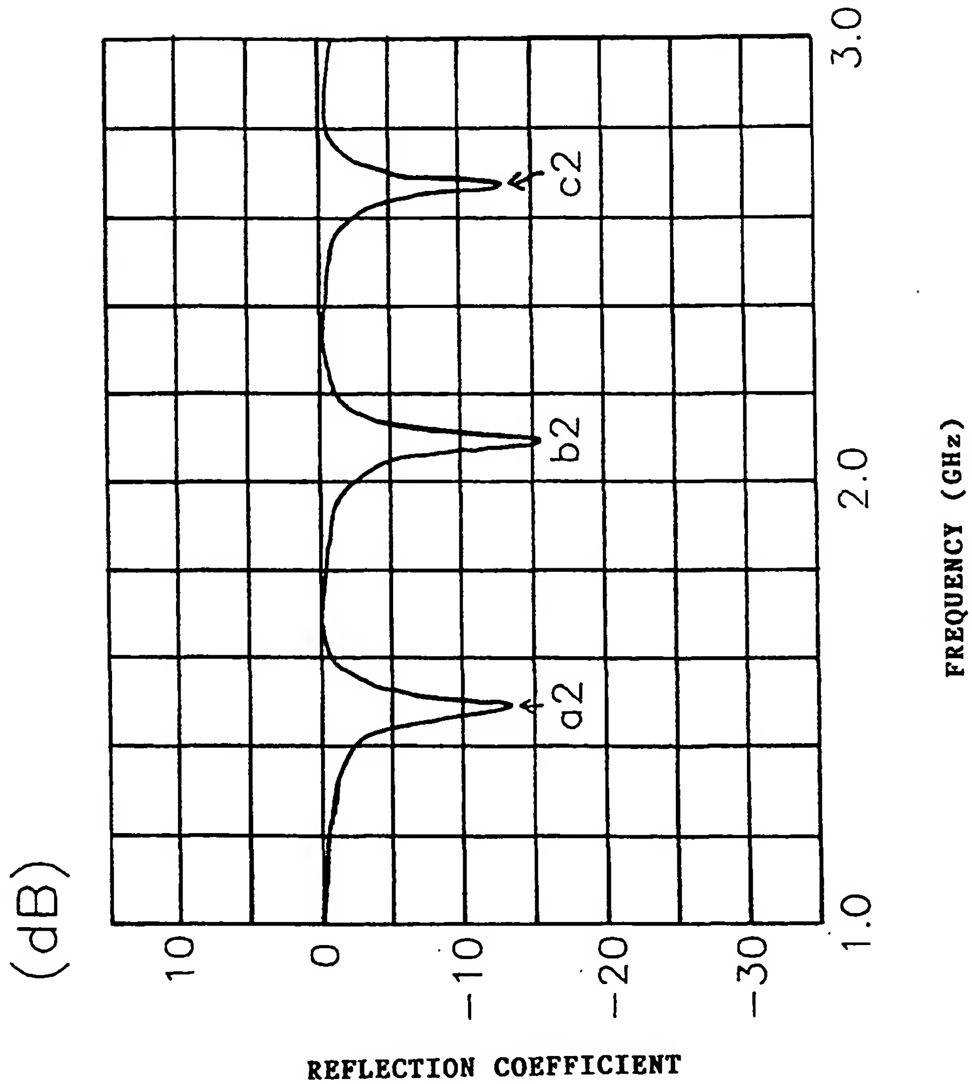
24d
24a
24b
24c


(dB)
10
0
-10
-20
-30
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2.0
3.0
a2
b2
c2
FREQUENCY (GHz)
REFLECTION COEFFICIENT

FIG. 6

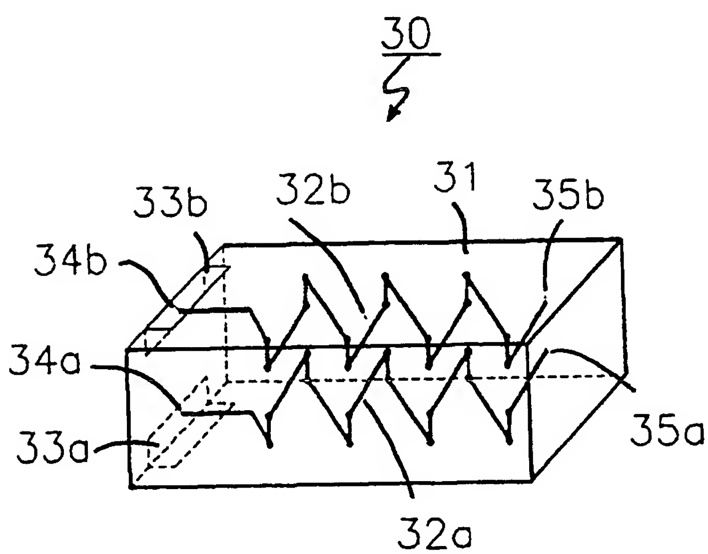

FIG. 7

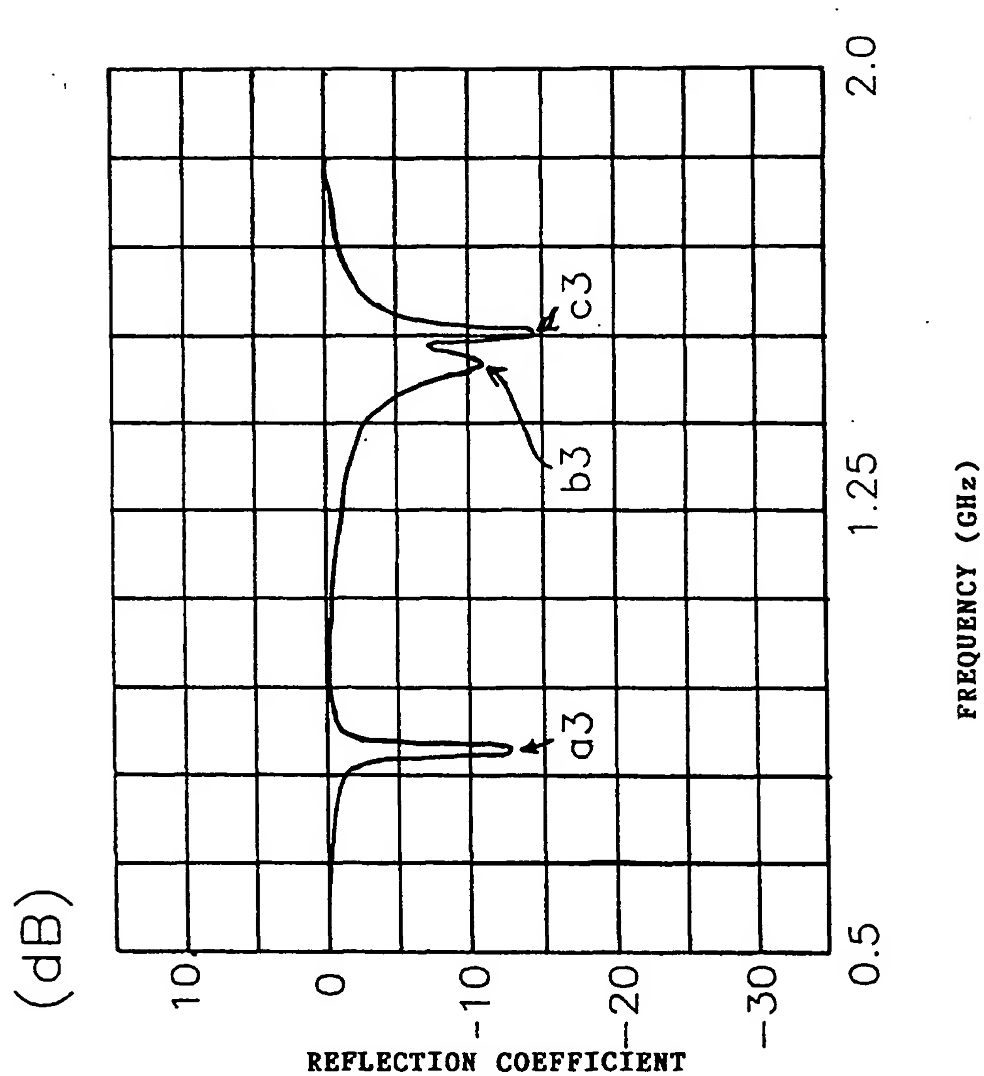
(dB)
10
0
-10
-20
-30
REFLECTION COEFFICIENT
0.5
1.25
2.0
FREQUENCY (GHz)
a3
b3
c3

FIG. 8

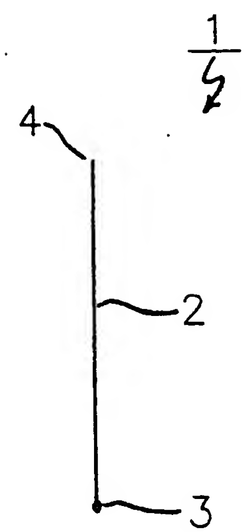

FIG. 9

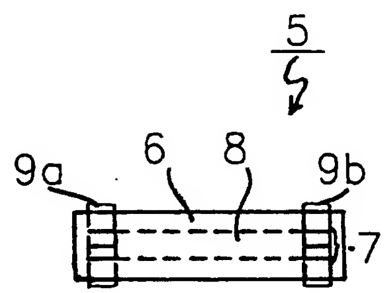

FIG. 10